

How Central are Local Centres? Testing Archaeological Hypotheses of the Dutch Part of the Roman Limes through Spatial Analysis and Network Science

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The integration of the Dutch Rhine-Meuse delta in the Roman Empire during the first centuries AD is thought to have led to an increased structuring of the settlement pattern and an increased level of interaction between the rural population and the military population that resided in the forts (*castella*) along the Rhine (fig. 1). The manner through which this interaction took place, for example in the form of the distribution of surplus-produced goods, is relatively unknown. Roman archaeologists such as Willem Willems and Wouter Vos have argued that the Dutch limes zone can be characterised by a dendritic settlement system, particularly for the (re)distribution of goods, wherein most interactions moved up and down this hierarchic system and fairly little ‘horizontal’ interaction took place. Besides the known rural centres, Wouter Vos in his study of the Kromme Rijn region also sees a role in this system for some atypical rural settlements.¹

This study makes use of two contrasting hypotheses: a null hypothesis, in which all surplus-produced goods flow directly from each rural settlement to a *castellum*, and an alternative hypothesis in which goods from individual settlements flowed to a more centrally located gathering point such as a storage facility or local market, i.e. the ‘local centres’ or ‘intermediary sites’ in the dendritic hierarchic system, from which bulk transport destined for the *castella* was organised (fig. 2). Since one of the primary costs of transport is the time investment, these hypotheses can essentially be compared on the basis of the time advantage that one of these systems has over the other.

This study makes use of a transport network modelled on the basis of a least-cost path approach that connects the rural settlements to each other and to the *castella*. The cost of movement between two places over such a network is expressed in units of time.² The aforementioned hypotheses can be tested using path length, a concept of network analysis, which in the modelled networks is therefore also expressed in units of time. For the alternative hypothesis to be more efficient than the null hypothesis, the total path length to reach an intermediary site from a number of rural settlements (in this study set at 25) in addition to the path length of that intermediary site to a *castellum* should be lower than the total path length of the same number of rural settlements to reach the *castellum* directly. Using this approach, the hypotheses essentially also test whether or not the sites that have been identified as potential ‘intermediary sites’ are indeed more ‘central’ in the distribution of goods in a dendritic system than the *castella* themselves.

For the *castella* in the westernmost part of the study area (Katwijk-Brittenburg, Valkenburg and Leiden-Roomburg), it is found that the alternative hypothesis is more

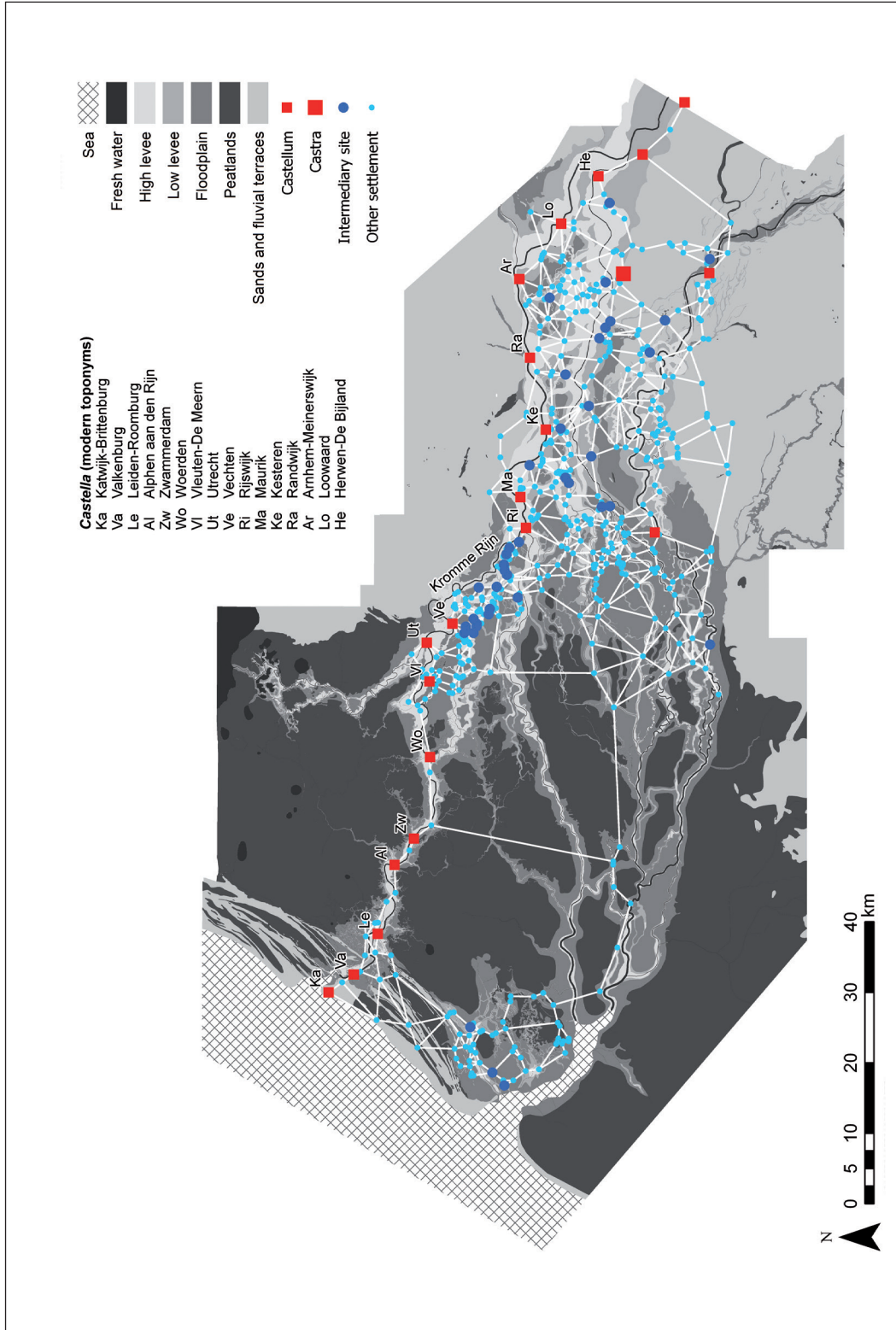


Fig. 1: Palaeogeographic map of the study area, showing castella, rural settlements and potential intermediary sites, as well as toponyms referenced in the text.

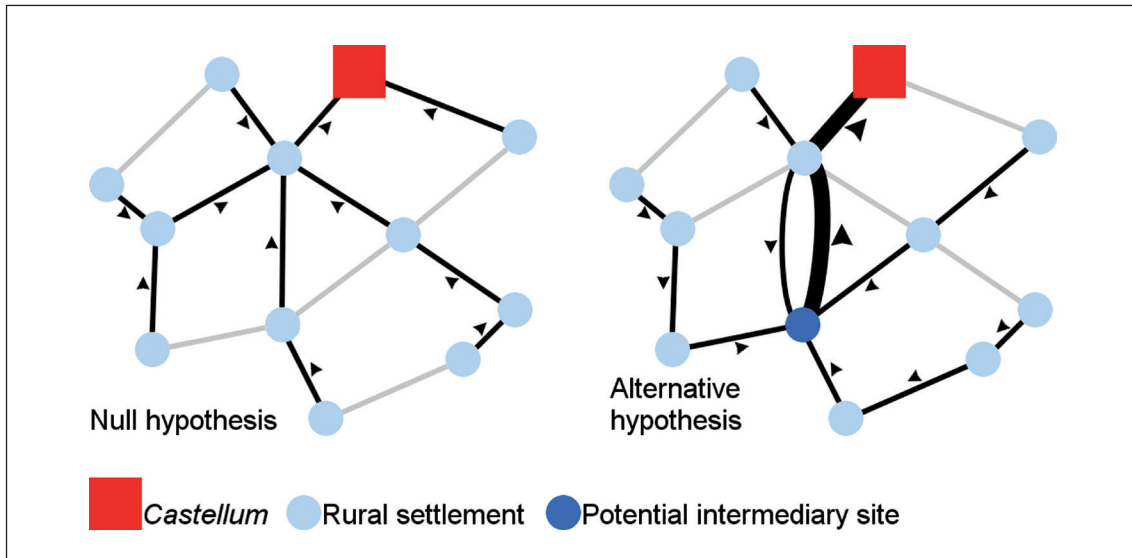


Fig. 2: Schematic examples of the null hypothesis (all goods flow directly to the castellum) and the alternative hypothesis (all goods flow to the intermediary site, and are subsequently moved in bulk to the castellum).

likely than the null hypothesis, indicating that it would be more efficient to move goods through intermediary sites rather than directly to the *castella*. However, it is noteworthy that the potential intermediary sites are all far removed from the forts, creating the possibility for a dual system wherein the *castella* have functioned as gathering sites for their direct vicinity, while at the same time some intermediary sites functioned as gathering sites for settlements further away.

The *castella* along the narrowest section of the Rhine channel belt (Alphen aan den Rijn, Zwammerdam and Woerden) have no intermediary sites closer to them than to any other *castellum*. Furthermore, there are so few rural settlements in their vicinity that their total path length to the 25 nearest settlements is much larger than that of other *castella*. It is therefore imaginable that these forts relied on their direct hinterland to a limited extent, in which they functioned as direct gathering sites, but were also dependent on regional provisioning lines for their requirements, including transport over the Rhine from the central and eastern parts of the Rhine-Meuse delta. The *castella* of Vleuten-De Meern and Utrecht are closer to the densely populated Kromme Rijn region and can to some extent be expected to have relied on that hinterland for their provisioning. This is reflected in their lower total path length compared to the three forts to their west. Similarly, these two forts may have functioned as gathering sites for settlements in their immediate vicinity, while at the same time relying on more distant intermediary sites, most likely in the Kromme Rijn region, to supplement their requirements.

In the Kromme Rijn region it is found that the alternative hypothesis is more likely than the null hypothesis, in particular for those sites identified as large rural settlements

by Vos,³ indicating that it would be more efficient to move goods through these intermediary sites than directly to one of the two *castella* (Vechten and Rijswijk). In contrast to the intermediary sites found in the western part of the study area, these sites are actually located between the forts rather than in more distant areas, indicating that a hierarchic settlement system in this part of the study region would be beneficial for local scale transport. Furthermore, the intermediary sites that are further away actually have a higher total path length than the forts, which leads to the conclusion that they may not have been intermediary sites in local transport networks, or that they may have functioned as such in a different context (e.g. as part of a Meuse-based transport network).

From the *castella* of Maurik to Herwen-De Bijland, all forts have at least one intermediary site closer to them than to any other *castellum*. These intermediary sites all have a lower total path length from their 25 nearest rural settlements than the *castella* themselves. It can thus be concluded that the alternative hypothesis is more likely for these forts: it would be more efficient to move goods through an intermediary site than directly to the *castella*, and in this case it is true both for intermediary sites that are near to the *castella* and those that are in more distant areas.

This study has given important insights into the possible functioning of military provisioning from the local hinterland, and has supported and refined current archaeological thinking about these socio-economic interactions between the local population and the Roman military population. Furthermore, this study has shown that by expressing our archaeological ideas into relatively simple testable hypotheses, we can use methods from spatial analysis and network science to further our archaeological understanding in a more quantifiable way.⁴

Notes

¹ Willems 1986; Vos 2009.

² Groenhuijzen – Verhagen 2015; Groenhuijzen – Verhagen 2017.

³ Vos 2009.

⁴ Groenhuijzen 2018.

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